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RESEARCH MEMORANDUM

THE AERODYNAMIC EFFECTS OF ROCKETS AND FUEL TANKS MOUNTED UNDER THE SWEPT-BACK WING OF AN AIRPLANE MODEL

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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RESEARCH MEMORANDUM

THE AERODYNAMIC EFFECTS OF ROCKETS AND FUEL TANKS MOUNTED UNDER THE SWEPT-BACK WING OF AN AIRPLANE MODEL

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SUMMARY

The effects of externally mounted rockets and fuel tanks on the aerodynamic characteristics of an airplane model with a swept-back wing are presented in this report. The drag coefficient at low lift coefficients of the airplane, as predicted from wind-tunnel tests of a semispan model, would be increased approximately 0.011 at 0.30 Mach number and about 0.025 at 0.875 Mach number by the addition of 10 rockets under each wing. The addition of the fuel tanks would increase the drag coefficient about 0.010 at 0.30 Mach number and about 0.016 at 0.85 Mach number. Both fuel tanks and rockets decreased the drag-divergence Mach number. No serious reduction of either longitudinal or lateral control was noted, and the longitudinal stability was not impaired.

INTRODUCTION

It is intended that this report supplement existing information on external stores by showing their effects on the aerodynamic characteristics of an airplane model with a swept-back wing. Because the streamlines in the horizontal plane over a swept-back wing are not parallel to the free stream, it was desirable to determine if the presence of external equipment on a swept-back wing produced more adverse effects than on a straight wing.

The data for this investigation were obtained from tests of the model in the Ames 16-foot high-speed wind tunnel.

SYMBOLS

The symbols used in this report, together with their definitions, are:

C_L lift coefficient $\left(\frac{\text{twice lift of half model}}{qS}\right)$

C_D drag coefficient $\left(\frac{\text{twice drag of half model}}{q\ S}\right)$

C_m pitching-moment coefficient about center-of-gravity of model $\left(\frac{\text{twice pitching moment of half model}}{q\ S\ \text{M.A.C.}}\right)$

α angle of attack of model, degrees

M Mach number $\left(\frac{V}{a}\right)$

C_l rolling-moment coefficient $\left(\frac{\text{rolling moment of half model}}{q\ S\ b}\right)$

δ_a aileron deflection about hinge line, degrees

δ_e elevator deflection about hinge line, degrees

N number of rockets on each wing

where

q dynamic pressure, pounds per square foot

S twice wing area of half model, square feet

M.A.C. mean aerodynamic chord, feet

b twice wing span of half model, feet

V free-stream velocity, feet per second

a velocity of sound, feet per second

MODEL AND APPARATUS

The left half of a 0.20-scale model of a fighter airplane with a 35° swept-back wing was employed in these tests. The half model was mounted on the trunnion of the wind-tunnel balance frame with its center line approximately 6 inches from the tunnel wall. A steel separation plate served as a reflection plane for the half model. (See reference 1 for sketch and more complete details of the installation.)

The rockets used during the investigation were 0.20-scale models of 5-inch rockets. They were made of solid aluminum and were mounted under the wing on aluminum hangers. (See fig. 1.) The hangers were so arranged that either a single or double row of from one to five rockets each could be fastened to the wing. (See fig. 2.)

The fuel tank, which was a scale model of a 193-gallon external wing tank, was made of laminated mahogany and mounted under the wing by means of a cast-aluminum streamline bracket. (See fig. 3.)

[redacted]

Pertinent model dimensions are:

Wing area (twice area of semispan model), sq ft	11.516
Mean aerodynamic chord, ft.	1.617
Wing span (twice span of half model), ft.	7.424
Wing airfoil section	
Root.	.NACA 0012-64 modified
Tip	.NACA 0011-64 modified

(See reference 1 for more complete table of dimensions.)

TESTS

Four combinations of rockets were tested (fig. 2) to determine the general effects on the characteristics of the model, to ascertain if the proximity of the rockets to the aileron affected the control characteristics, and to discover if the effectiveness of the horizontal tail was impaired. The investigation of the model with the fuel tank was limited to a determination of the basic aerodynamic characteristics.

Corrections applied to the data may be found in reference 1.

The four rocket combinations tested were as follows:

10 rockets in 2 horizontal rows of 5 each
8 rockets in 2 horizontal rows of 4 each
4 rockets in 2 horizontal rows of 2 each
4 rockets in 1 horizontal row

(See fig. 2 for a sketch of these combinations.) The four arrangements will be referred to as: double row of 10 rockets, double row of 8 rockets, double row of 4 rockets, and single row of 4 rockets, respectively.

It must be kept in mind that the various arrangements of external stores are designated by reference to the combination attached to one wing panel only; but that the accompanying data are for one such combination under each wing. For example, when reference is made to a double row of 10 rockets the results presented show the effects to be expected from a double row of 10 rockets mounted under each wing.

RESULTS AND DISCUSSION

The data obtained from tests of the rockets are presented in figures 4 through 10, and the results for the fuel tanks are shown in figures 11 through 14.

During the investigation of the rockets the fuselage of the model was modified a number of times. However, in any single figure of this report comparison is made between tests with identical fuselages.

Further comparison should be limited to consideration of increments only.

The lift and pitching moment of the model were not affected to any serious extent by the addition of a double row of 10 rockets, as indicated in figures 4 and 5. However, the drag coefficient of the model was increased approximately 0.011 at 0.30 Mach number and about 0.025 at a Mach number of 0.875 at low lift coefficients. (See fig. 6.) From comparative data for different combinations of rockets (fig. 7) it may be seen that the increase in drag is approximately proportional to the number of rockets. Figure 8 gives the variation of incremental drag coefficient with the number of rockets at two lift coefficients. Further examination of figure 7 indicates that all combinations of rockets caused the drag characteristics to diverge at a lower Mach number than the characteristics of the model alone.

In general, the presence of the rockets on the wing of the model did not have serious effects on the control characteristics. Both aileron and elevator suffered only slight loss of effectiveness throughout the range of the test. (See figs. 9 and 10.)

The external fuel tank caused a decrease of the lift-curve slope, especially at high Mach numbers. (See fig. 11.) At low lift coefficients the increase of drag coefficient due to the addition of the tank was about 0.010 at 0.30 Mach number and about 0.016 at a Mach number of 0.85. (See fig. 12.) The Mach number at which the drag coefficients diverged was decreased about 0.10 at a lift coefficient of zero and about 0.03 at a lift coefficient of 0.40. (See fig. 13.) The fuel tank contributed a climbing moment to the model, but did not affect the static longitudinal stability. (See fig. 14.)

CONCLUDING REMARKS

The semispan model tests of this report indicate that the drag coefficient at low-lift coefficients of the corresponding airplane would be increased approximately 0.011 at 0.30 Mach number and about 0.025 at 0.875 Mach number by the addition of 10 rockets under each wing. The addition of the fuel tanks would increase the drag coefficient about 0.010 and 0.016 at Mach numbers of 0.30 and 0.85, respectively. The Mach number of divergence was decreased by the addition of either the rockets or the fuel tank.

The fuel tank caused a decrease in the lift-curve slope, and both the tank and rockets caused a shift in the trim of the model. However, no important effect on the static longitudinal stability was noted.

The control characteristics were not materially affected by either the rockets or the fuel tank.

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REFERENCE

1. Boddy, Lee E., and Morrill, Charles P., Jr.: The Aerodynamic Effects of Modifications to the Wing and Wing-Fuselage Intersection of an Airplane Model with the Wing Swept Back 35°. NACA RM No. A7J02, 1947.

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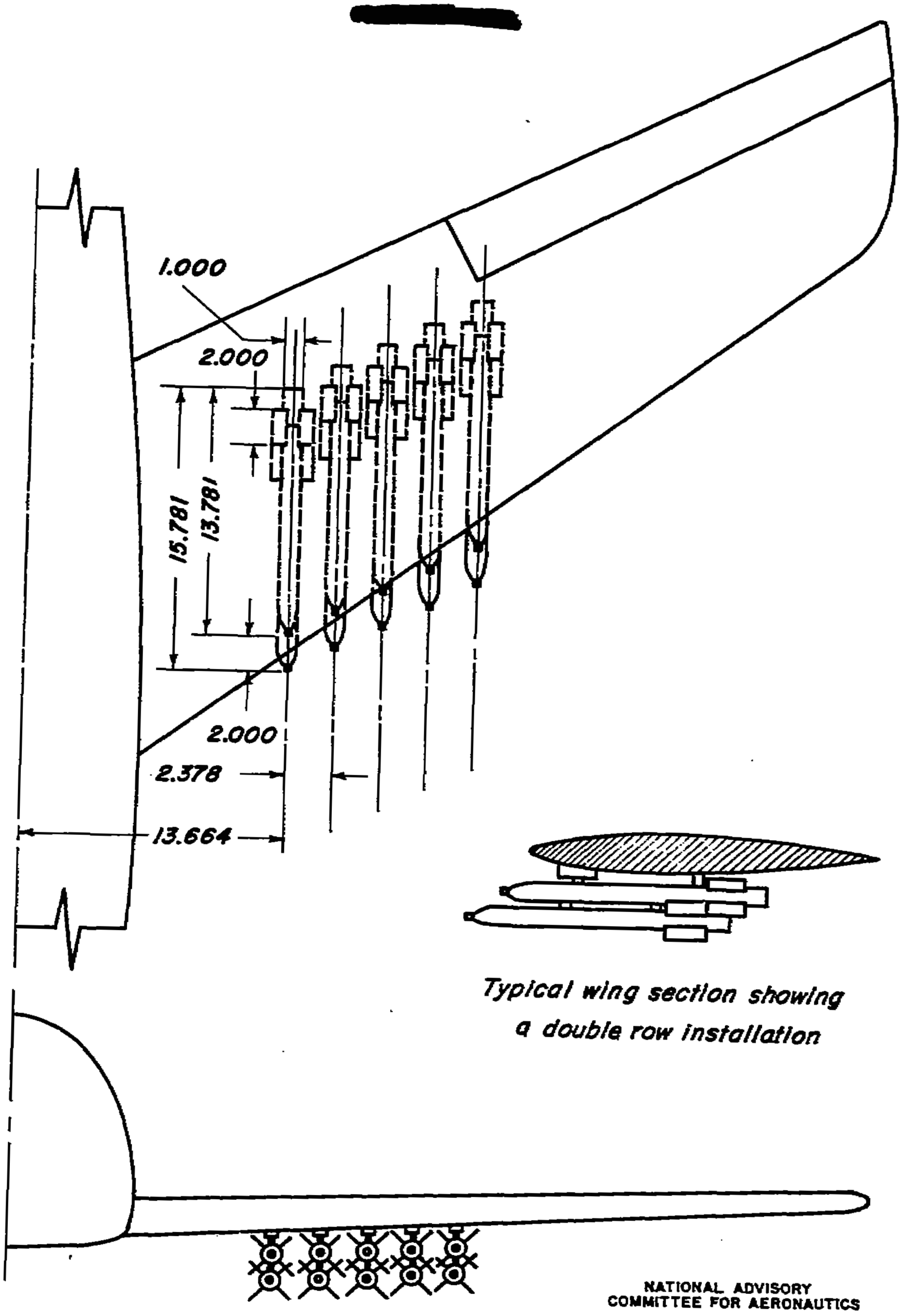

Figure 1.— Rocket installation.

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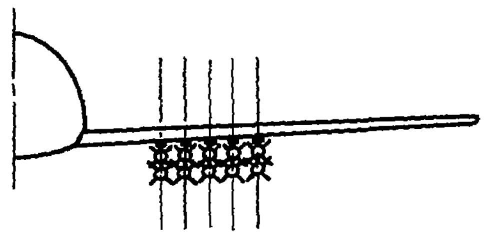
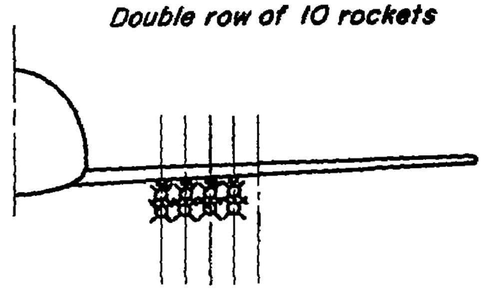
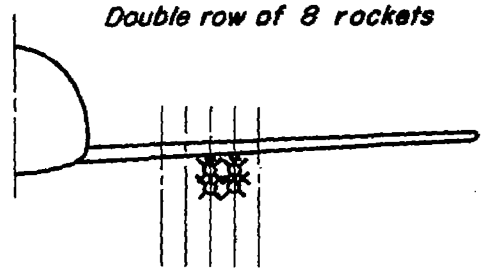


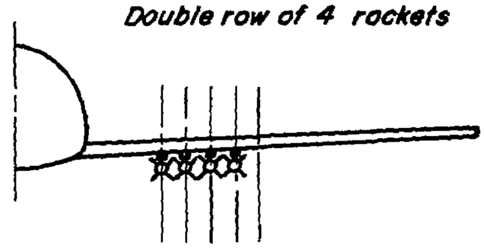
Double row of 10 rockets



Double row of 8 rockets



Double row of 4 rockets



Single row of 4 rockets

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Figure 2.— Rocket combinations tested.

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[redacted]

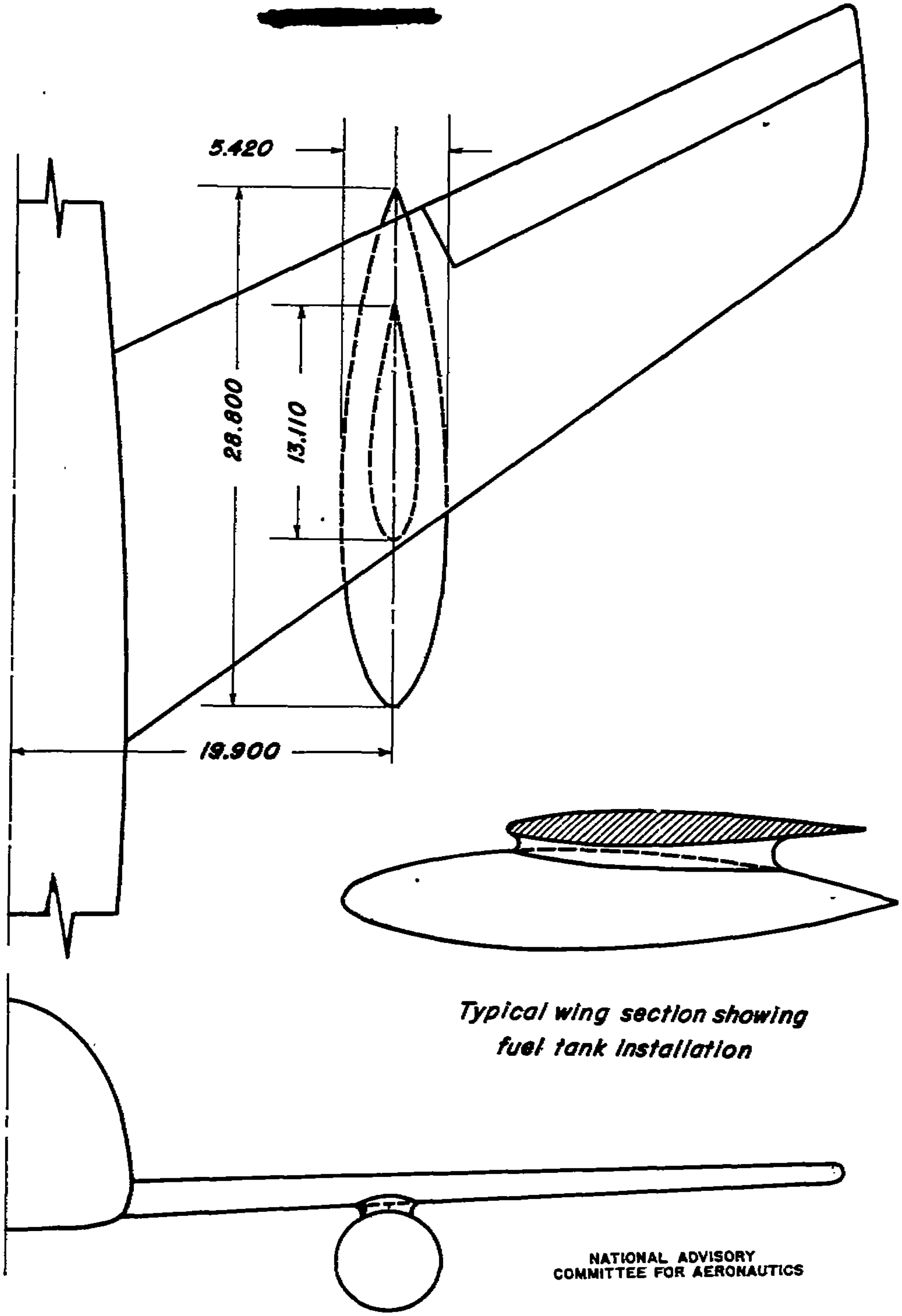


Figure 3.— External fuel tank installation.

[redacted]

[redacted]

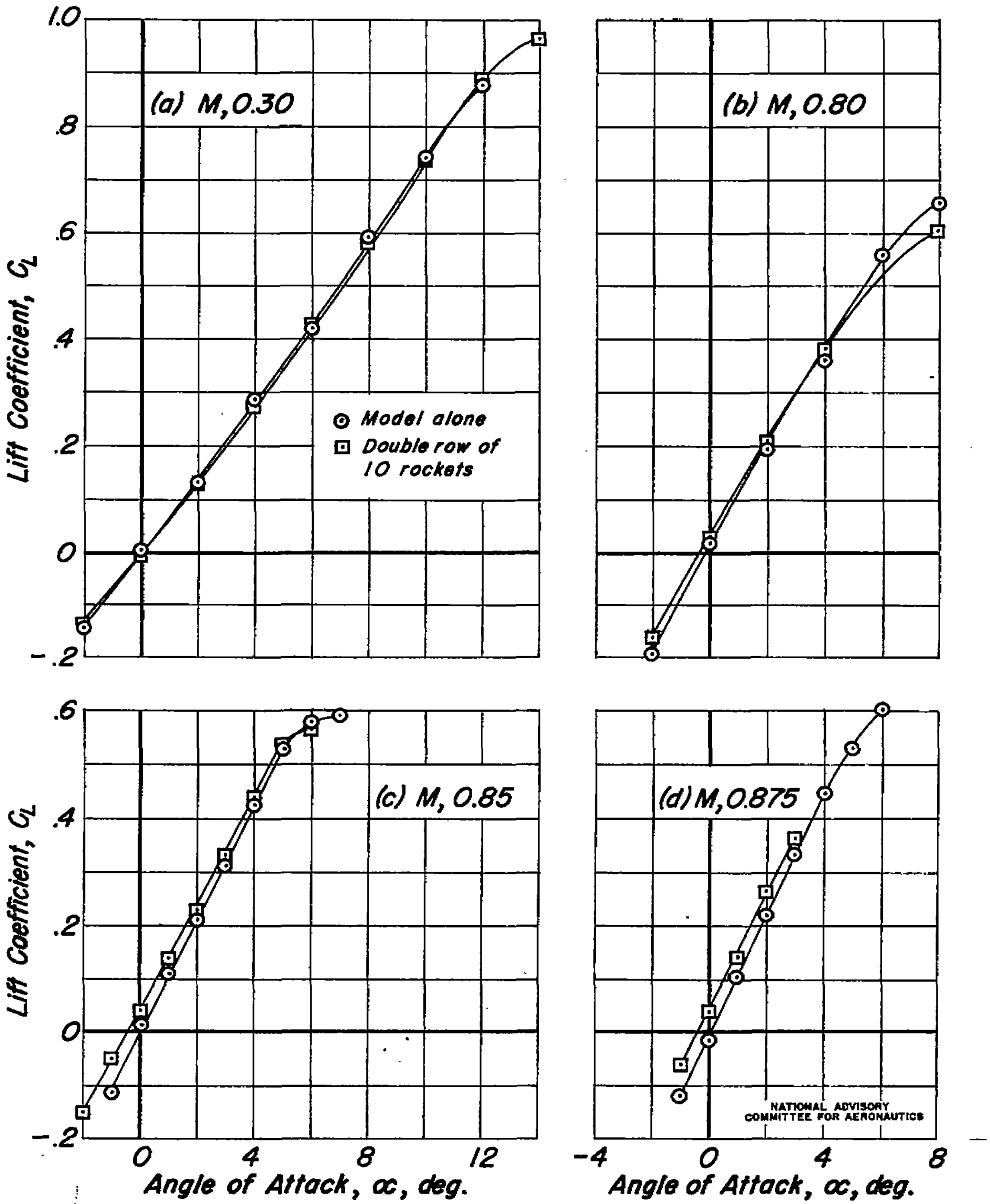


Figure 4.— Lift characteristics of the model with and without rockets.

[redacted]

[redacted]

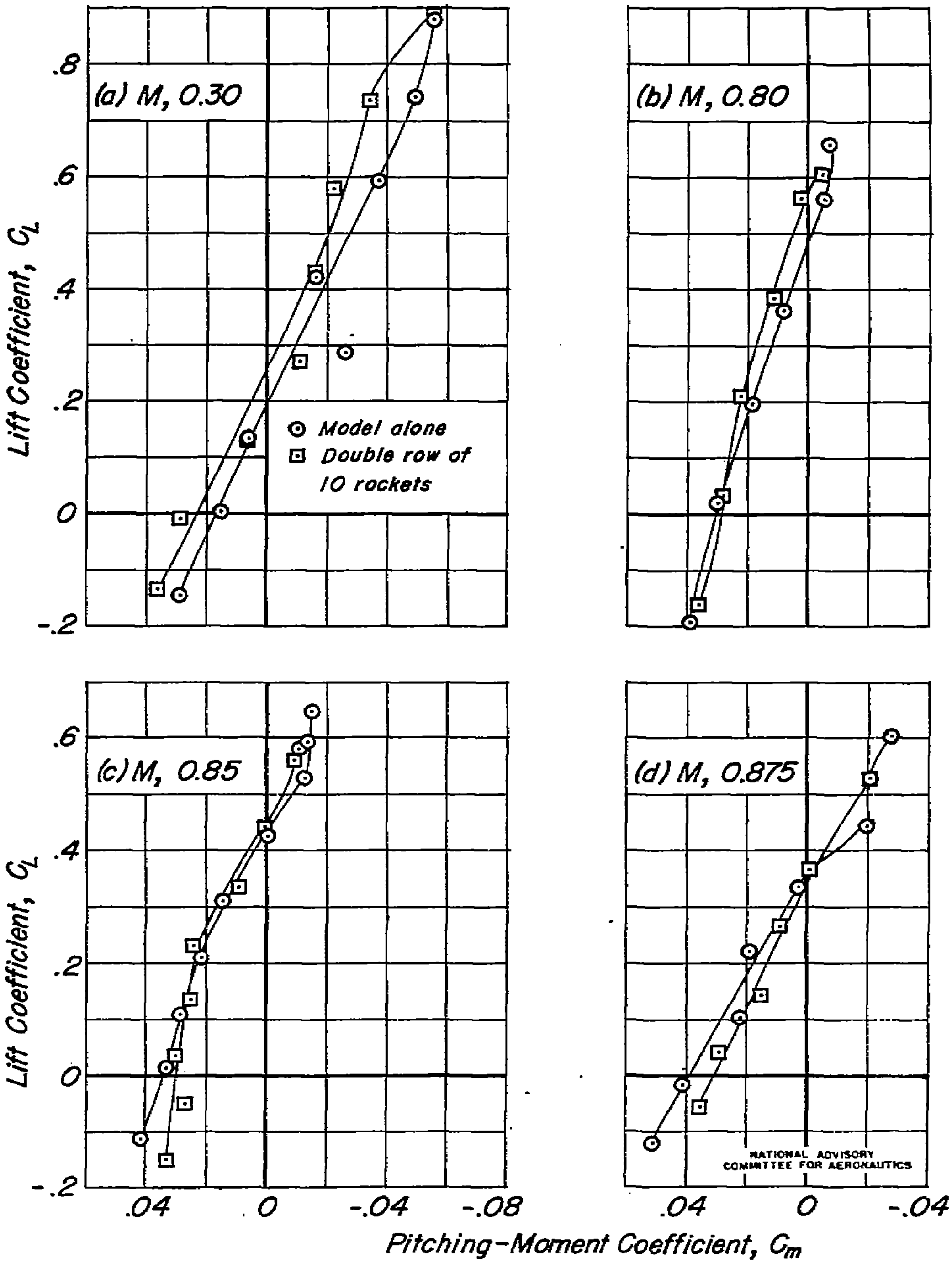


Figure 5.— Pitching-moment characteristics of the model with and without rockets.

[redacted]

[redacted]

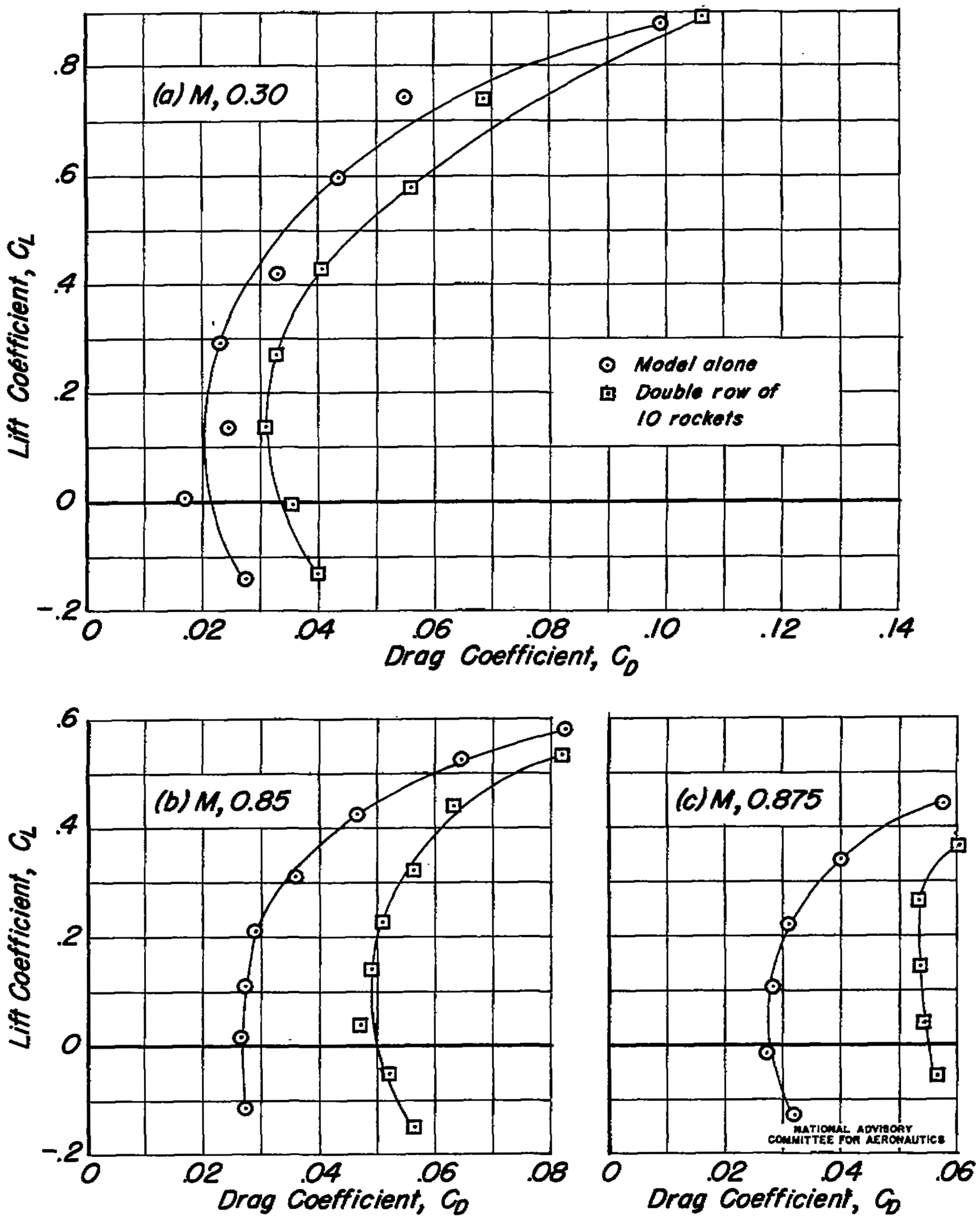
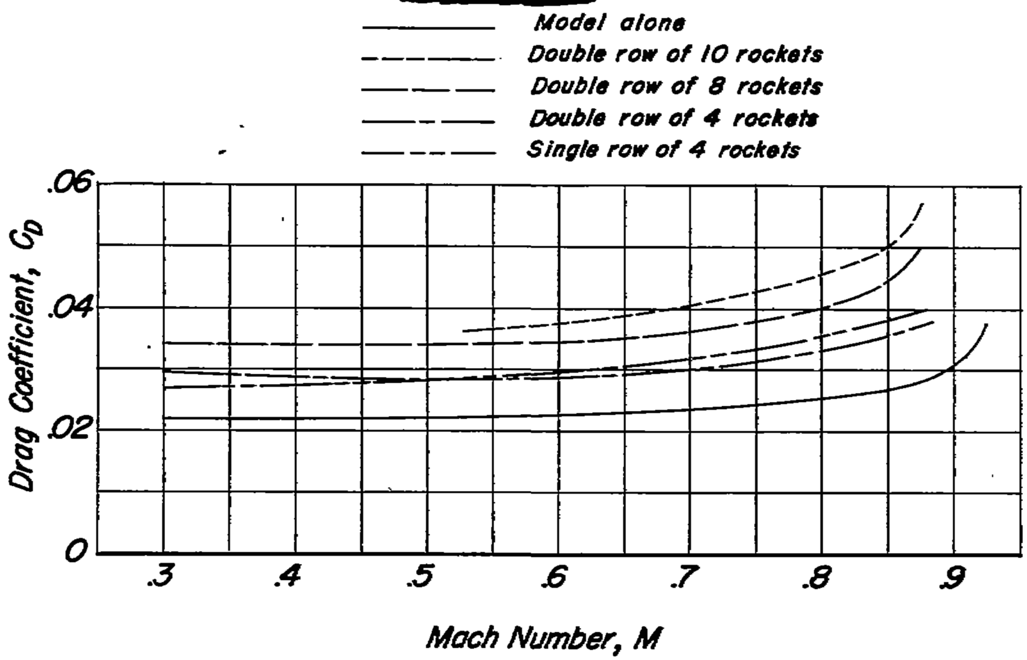


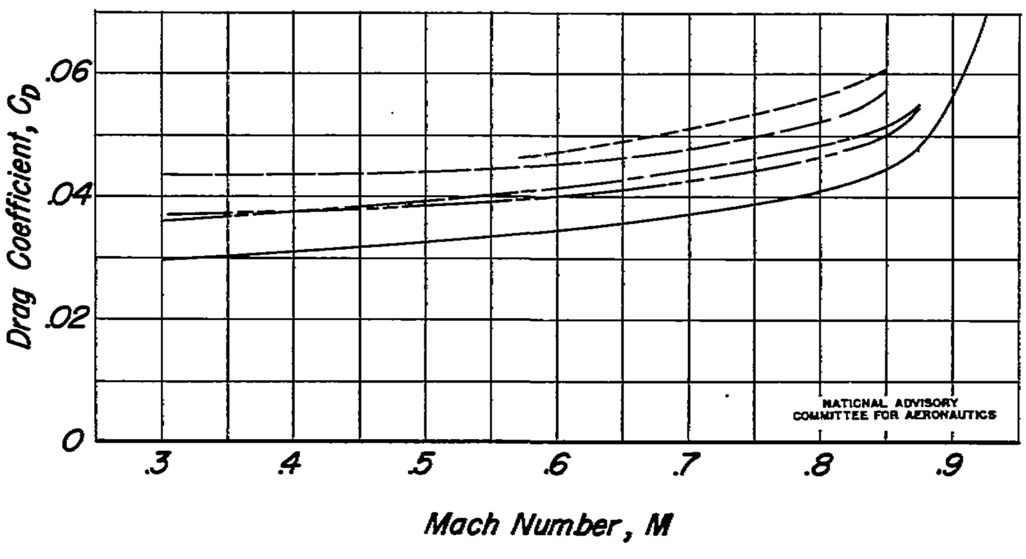
Figure 6.– Drag characteristics of the model with and without rockets.

[redacted]

[redacted]



(a) C_L, 0



(b) C_L, 0.4

Figure 7.—Variation of drag coefficients with Mach number for several rocket combinations.

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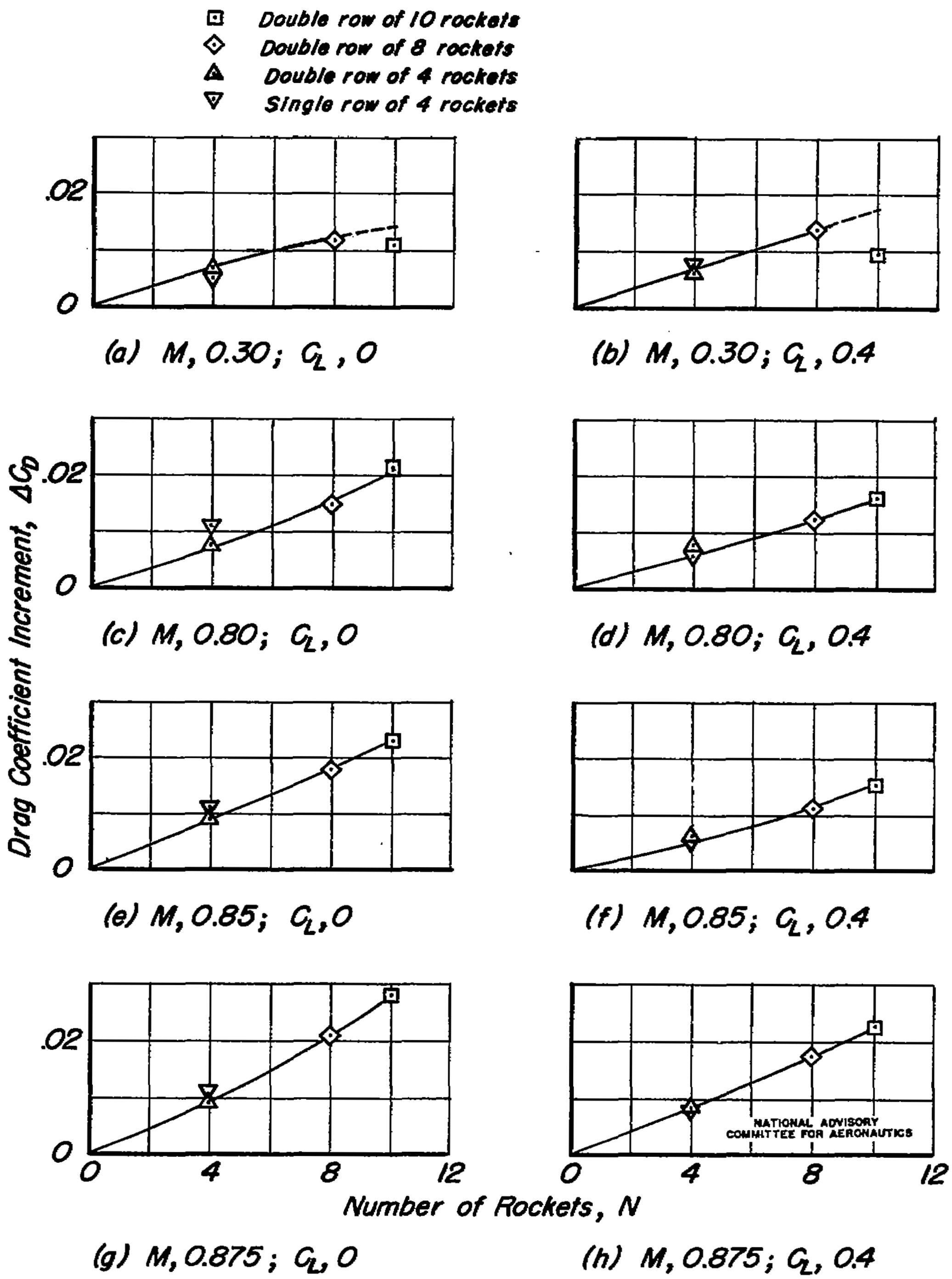

Figure 8.— Variation of drag coefficients with number of rockets.

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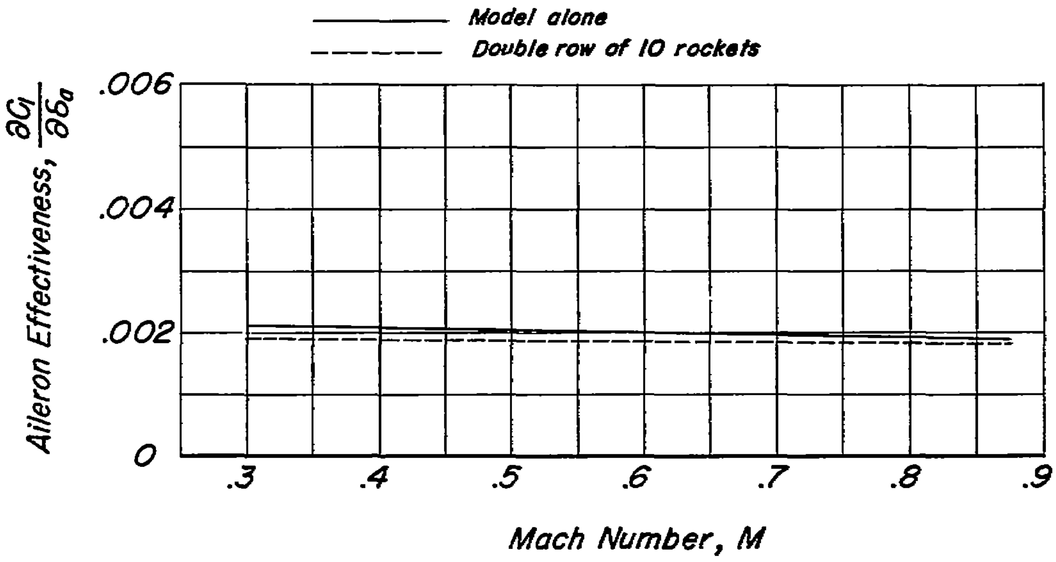
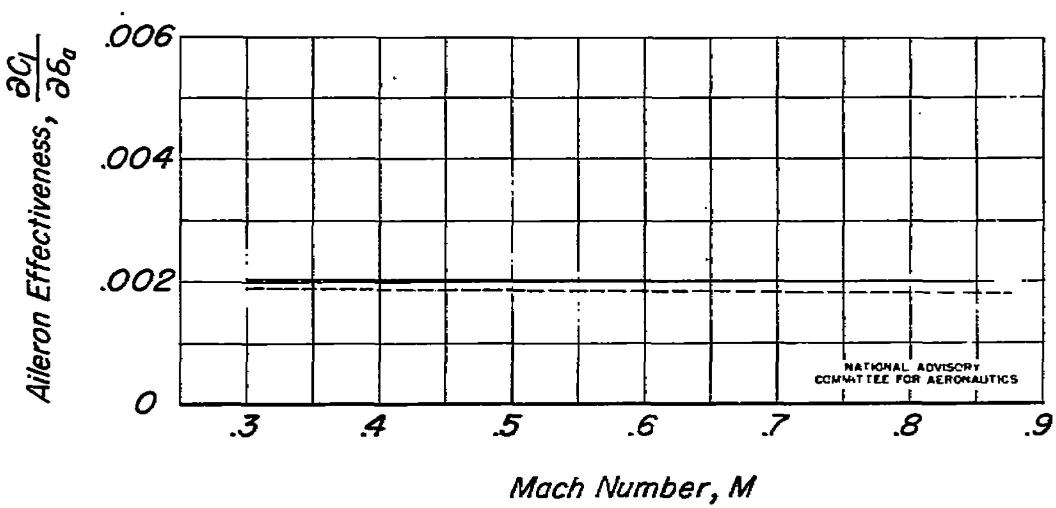


(a) C_L, 0



(b) C_L, 0.4

Figure 9.— Aileron effectiveness of the model with and without rockets.

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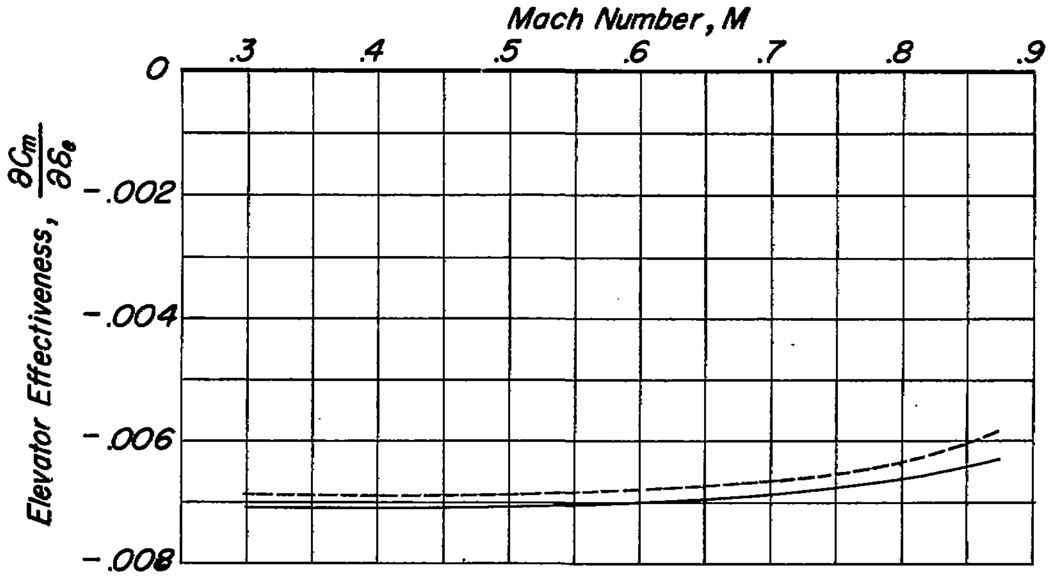
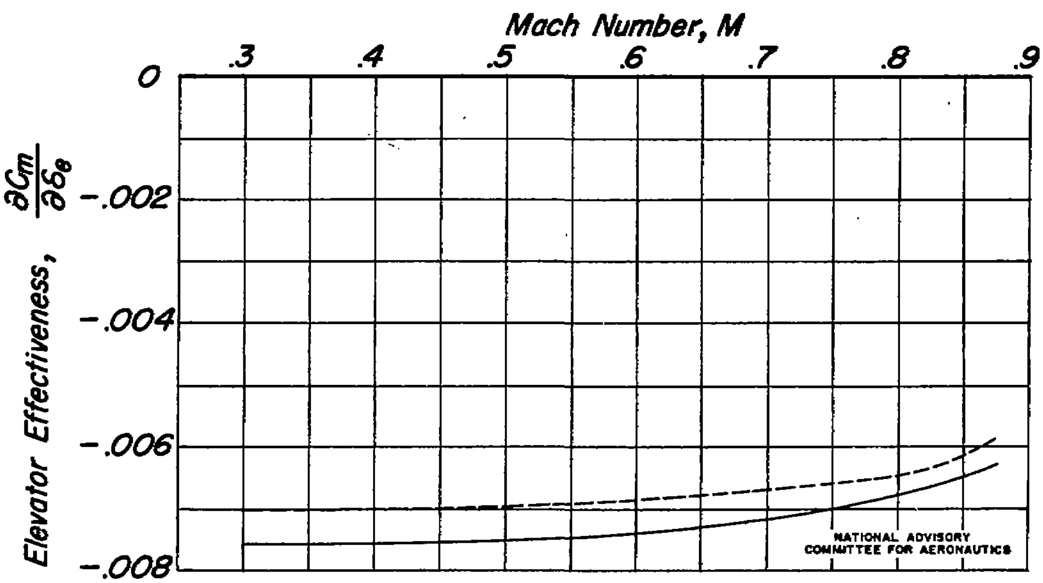


(a) α, 0°

Model alone
Double row of 10 rockets



(b) α, 4°

Figure 10.—Elevator effectiveness of the model with and without rockets.

[redacted]

[redacted]

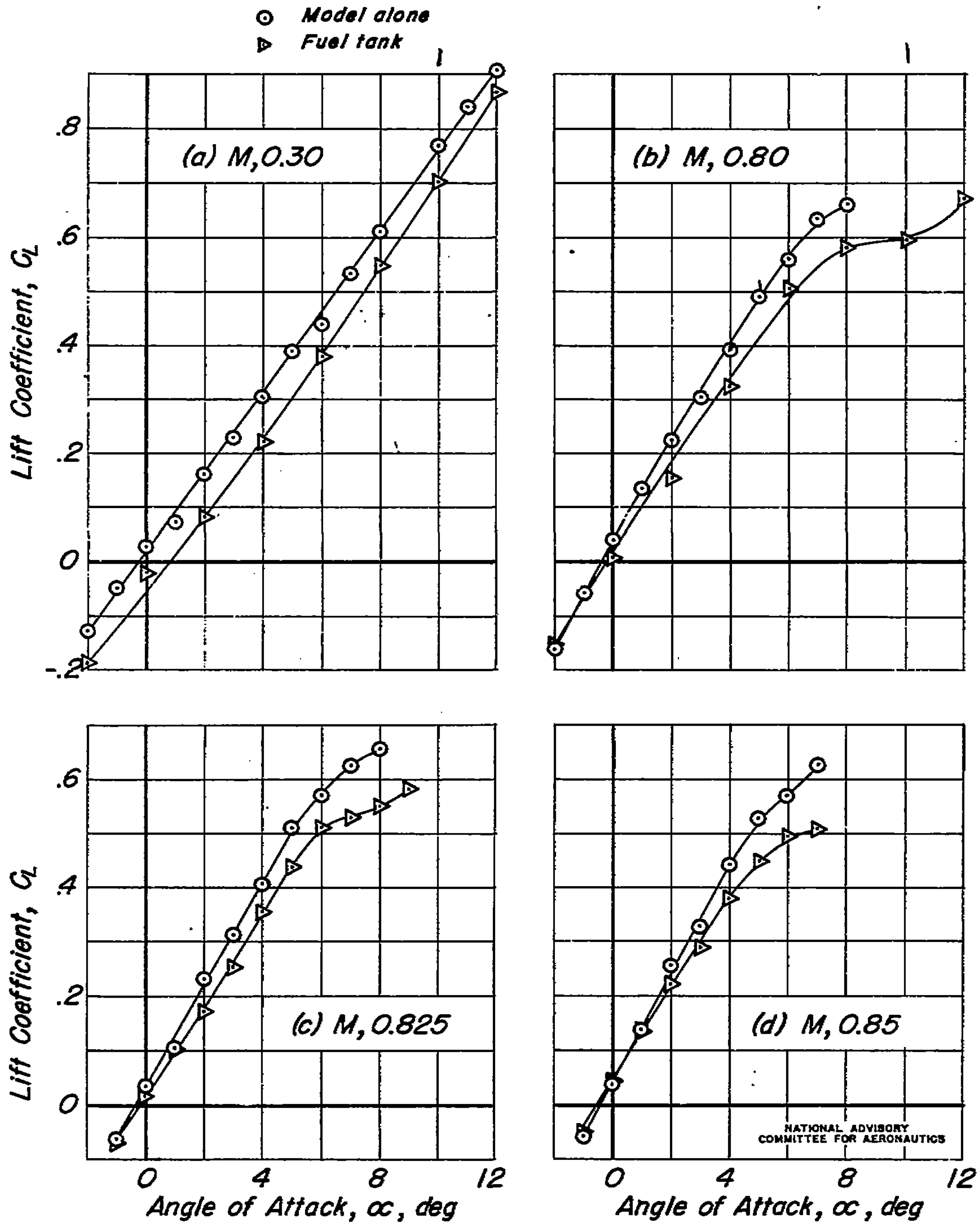


Figure 11.—Lift characteristics of the model with and without fuel tank.

[redacted]

[redacted]

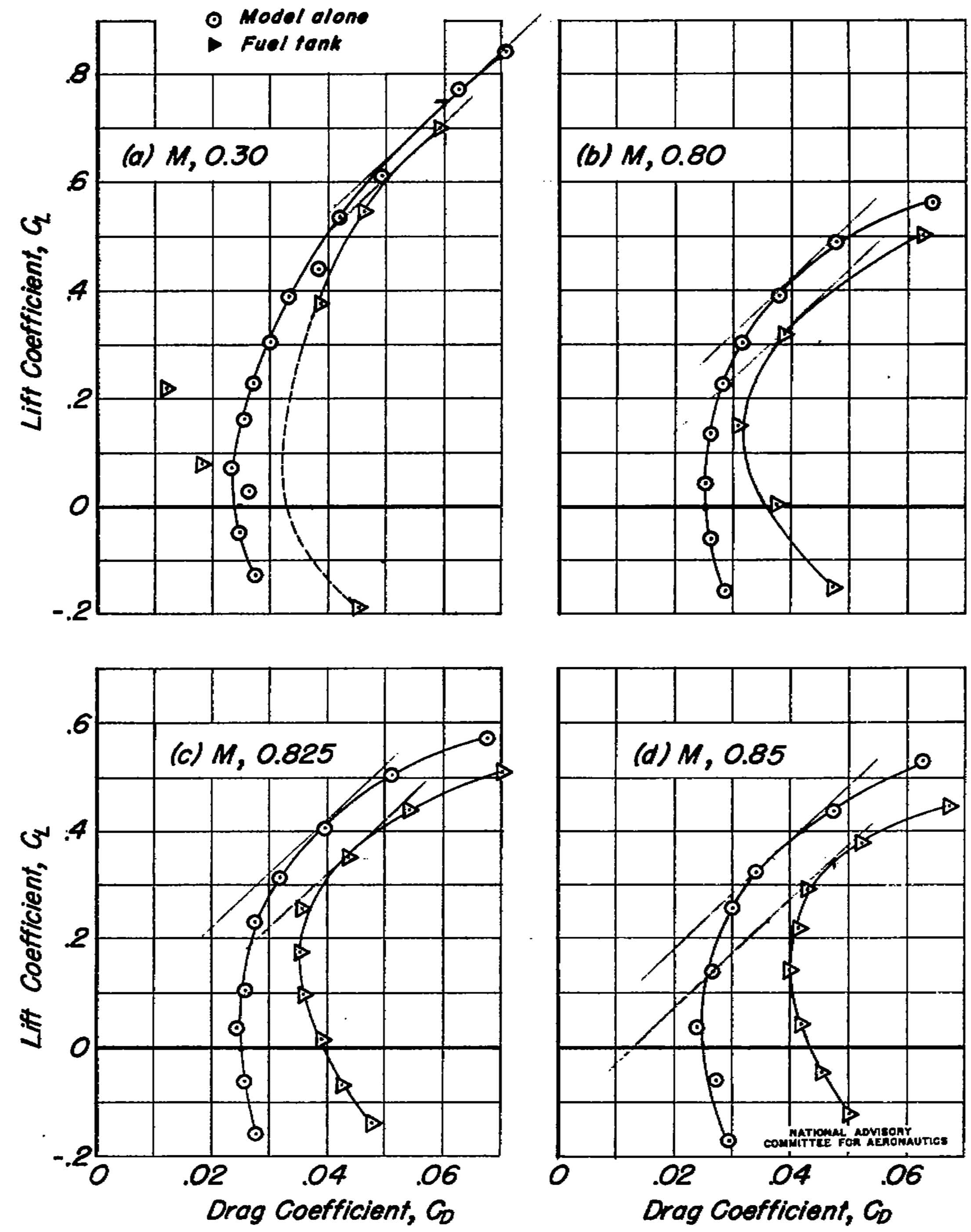
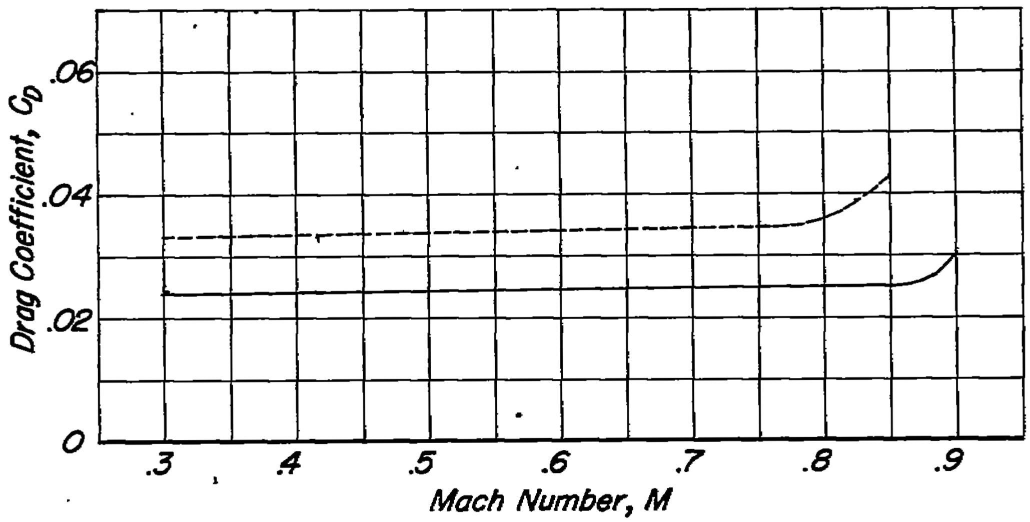


Figure 12.— Drag characteristics of the model with and without fuel tank.

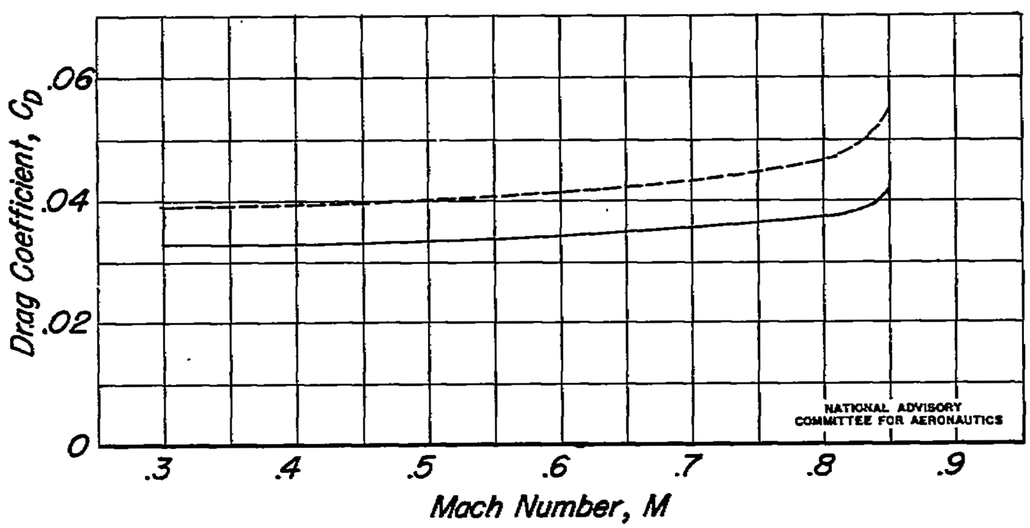
[redacted]

[redacted]



(a) C_L, 0

——— Model alone
– – – Fuel tank



(b) C_L, 0.4

Figure 13.—Variation of drag coefficient with Mach number of the model with and without fuel tank.

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[redacted]

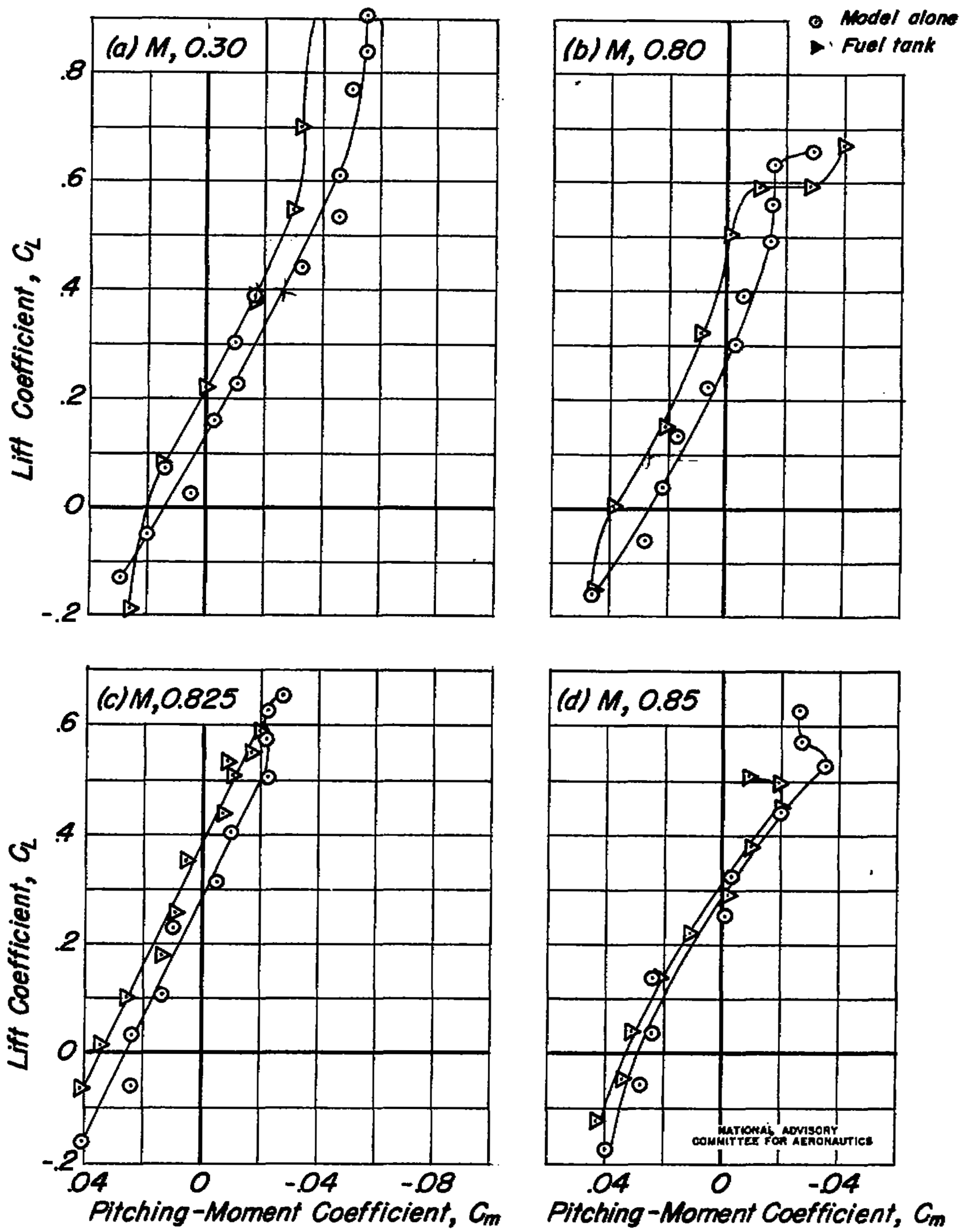

Figure 14.– Pitching–moment characteristics of the model with and without fuel tank.